

Figure 7  
Flow hydrographs of UVM delta outflow and mass-balance computed delta outflow for February to November 1996.

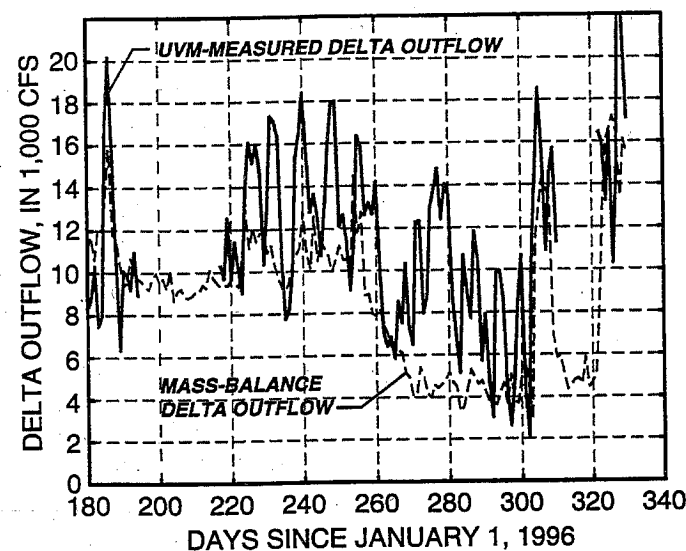


Figure 8  
Flow hydrographs of UVM delta outflow and mass-balance computed delta outflow for July to November 1996.

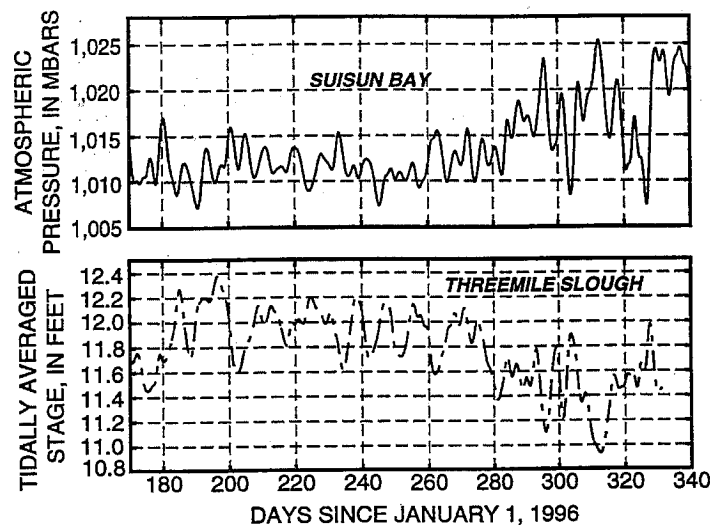


Figure 9  
Atmospheric pressure effects on delta outflow; atmospheric pressure recorded at Suisun Bay and tidally-averaged stage for Threemile Slough for July to November 1996.

relative to the mass-balance flows during this period which could be attributed to the draining of the Delta caused by the increase in atmospheric pressure.

Continuous monitoring of flow in four western Delta channels using UVMs and then combining the flow data collected at those stations to provide a measurement of Delta outflow appears to be feasible. A significant disadvantage of using four stations to measure Delta outflow is that if one station fails, a measurement of Delta outflow is not obtainable. During 1997, one of the four UVM stations was not operational for about 60 percent of the year due to damage sustained during the January 1997 floods or transducer piles being destroyed by passing vessels. In an attempt to reduce station down time, new heavy-duty transducer cable was installed to replace damaged cables, and the transducer pile at the San Joaquin River station was relocated hopefully out of harms way. Periodic data of measured Delta outflow are available for 1997, but not shown here. Advantages of using four stations include being able to measure QWEST indirectly, learning more about the hydrodynamics of the Delta than possible with only one flow record, and having more flow data available to calibrate numerical models. The data presented here show that the use of the mass-balance method to obtain an estimate of Delta outflow is probably adequate for most applications for medium- to high-flow periods. However, for low-flow periods, the effects of the spring-neap tidal cycle, atmospheric pressure changes, and the imprecision of estimates of Delta consumptive use may cause significant errors in the estimation of Delta outflow.

### Acknowledgments

The USGS greatly appreciates the funding provided by the DWR, USBR, State Water Resources Control Board, Contra Costa Water District, and the Department of the Interior Ecosystem Initiative Program to install and operate the four UVM flow monitoring stations needed to indirectly measure Delta outflow. The author acknowledges Mike Simpson, Rick Adorador, Jim DeRose, and Scott Posey (no longer with the USGS) of the USGS for their dedicated effort in the installation, troubleshooting, and operation of the UVM stations.

### Fishes Collected in Submersed Aquatic Vegetation, *Egeria densa*, in the Delta

Mike McGowan and Al Marchi, Romberg Tiburon Center for Environmental Studies, San Francisco State University

This study is to provide information to assess the potential effects on fishes of proposed Department of Boating and Waterway's (DBW) projects to control the nonnative invasive submersed aquatic plant *Egeria densa* in the Delta. DBW is performing a comprehensive evaluation of control methods and their potential effects, of which the fish study is one part. Key questions are (1) to what extent, if at all, do delta smelt, splittail, or migratory salmonids use *Egeria* beds as habitat, (2) what other fish species occupy the *Egeria*, and (3) how would reducing or eliminating the *Egeria* affect the fish community?

Following a literature survey and communication with specialists in California and in other states, pop-nets were selected as the best sampling device for fish in dense beds of aquatic plants. Four nets were constructed of plastic pipe, galvanized pipe, and 1.6 mm mesh nylon netting. The nets were 1 m<sup>2</sup> area by 3 m high between a floating top frame and a weighted bottom frame. A 1 m skirt with purse rings extended below the bottom frame. The frames, net, and skirt were deployed collapsed on the bottom surrounding 1 m<sup>2</sup> of *Egeria* bed.

After a 2-hour soak time, the top frame was released to float to the surface to enclose a column of water. The skirt was pursed underneath the bottom frame and then lifted to the surface, uprooting and collecting the

*Egeria* that was within the net frame. A few attempts were made to collect samples with a minnow seine and with a beach seine. We also searched for fishes by hand in truckloads of *Egeria* and other aquatic plants harvested from experimental plots.

The mean catch rate in 24 deployments of these pop-nets in three locations was 0.375 fish per m<sup>2</sup> (includes before and after mechanical harvesting). Proportion of samples positive for fish was 0.25, that is, one of four samples contained at least 1 fish. At this low catch rate, statistical comparisons could be misleading. Catch rates should be higher in spring and summer for improved statistical power. However, this size pop-net will be biased towards small fish associated with the *Egeria* canopy. Other gear will be needed to sample for large, less abundant fish, midchannel demersal fish (catfish), and schooling fish (shad, smelt).

The following trends in the data were noted but not tested statistically because of small sample sizes in this preliminary study. More fish were caught before harvesting *Egeria* than after harvesting at all three slough sites (Seven Mile, Sand Mound, White). Fish concentration with *Egeria* was similar, but total abundance increased from Seven Mile to Sand Mound to White sloughs because mean *Egeria* concentration per m<sup>2</sup> as sampled by pop-net increased from Seven Mile to Sand Mound to

White sloughs (Table 1.) Mean *Egeria* concentration per m<sup>2</sup> decreased after harvest at all three sites.

Pop-nets caught three species of fish: bluegill, redear sunfish, and largemouth bass. Additional fish were sorted from truckloads of plant material removed from the test sites by the harvester. The mechanical harvester caught the same three species as the pop-nets plus seven other species: warmouth, black crappie, goldfish, mosquito fish, golden shiner, threadfin shad, and inland silverside. No native species were collected. A beach seine caught the same three species as the pop-net, but bluegill and redear sunfish were larger than in the pop-net catches.

Concentration of fish captured by beach seine at Sand Mound Slough was 0.22/m<sup>2</sup> to 1.1/m<sup>2</sup> (entire area seined vs. area covered by *Egeria*). Using beach seine and minnow seine was impractical at most locations where dense beds of *Egeria* were found because of the soft, muddy slough bottom, tree snags, rules, riprap near shore, and general scarcity of beaches.

Mechanical harvesting incidentally captured a range of species and sizes of fish. The most abundant species (Figure 1) were the same ones collected by the pop-nets. However, the mechanical harvester collected some water hyacinth with the *Egeria* and operated at times in patches of open

Table 1. Fish Abundance Estimates by Area and Weight of *Egeria densa*

	Seven Mile Slough	Sand Mound Slough	White Slough
<i>Egeria</i> (g/m <sup>2</sup> ) by pop-net	859 ± 249 S.E.	947 ± 211 S.E.	2342 ± 632 S.E.
Fish (no./m <sup>2</sup> ) by pop-net	0.125	0.375	0.625
Fish (no./mt <i>Egeria</i> ) from harvested material	152 ± 150 S.E.	596 ± 391 S.E.	387 ± 210 S.E.

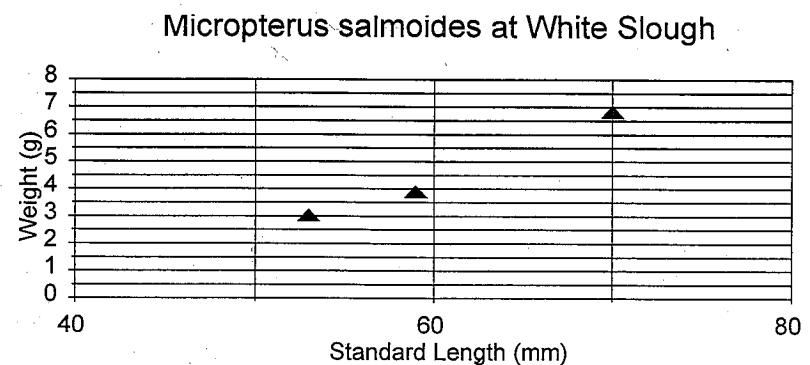
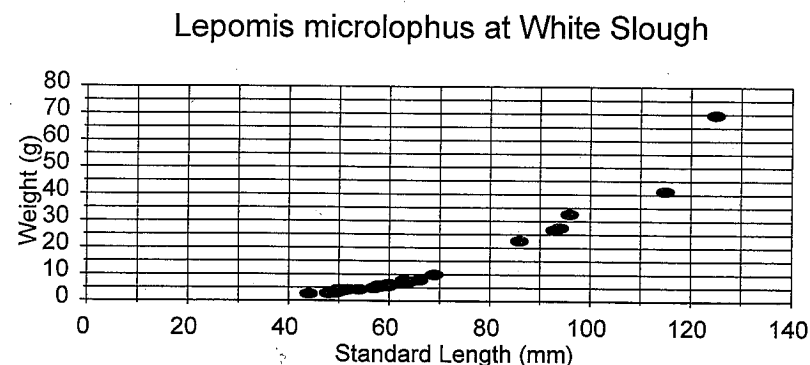
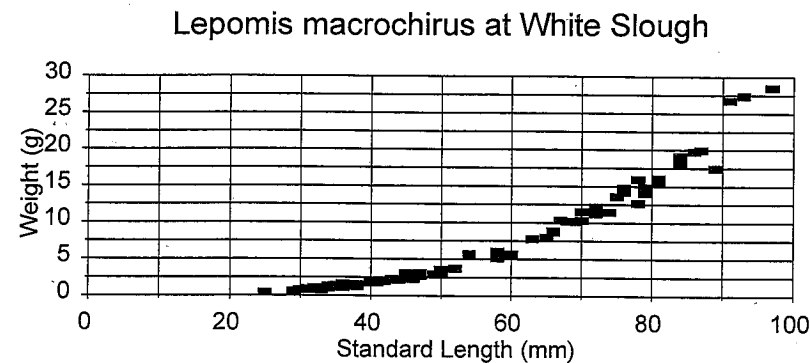


Figure 1  
Length-weight relationships of 88 bluegill (*Lepomis macrochirus*), 26 redear sunfish (*L. microlophus*), and 3 largemouth bass (*Micropterus salmoides*) sorted from 692 kg (1525 lb.) of *Egeria densa* harvested from White Slough.

## X2 Workshop

The IEP and the Bay/Delta Modeling Forum are sponsoring a one-day workshop on X2. The workshop will be held from 9 a.m. - 5 p.m. on Wednesday, March 11, 1998, at the Putah Creek Lodge on the UC Davis Campus. The morning session will include presentations by Wim Kimmerer, Bill Bennett, BJ Miller, Bruce Herbold, and Jon Burau. The afternoon session will consist of moderated panel discussion. There is no charge for the workshop itself, but attendees will be expected to contribute a nominal amount to cover lunch costs. For more information contact Randy Brown at [rbrown@water.ca.gov](mailto:rbrown@water.ca.gov).

water, so some species collected by harvesting may occur near the *Egeria*, but not necessarily within it.

### Future Plans:

1. Repeat the pop-net study at the three mechanical harvest sites in May and July as well as at three additional chemical control test sites. Increase the number of samples to improve the statistical precision of estimates.
2. Use light traps to sample fish larvae and juveniles at finer spatial scales, e.g., outer edge, interior of *Egeria* bed, inshore of *Egeria* bed in tules and water hyacinths.
3. Use seine or trawl to sample at larger spatial scale and to catch larger fish than with the pop-nets.
4. Continue the fish census in the harvested material to assess this as a method to monitor harvest impacts.

## Bay/Delta Email Reflector

As was mentioned a few issues ago, the IEP has established an email reflector to help disseminate Bay/Delta announcements and information. The list was recently tested with a message sending the announcement for the upcoming X2 workshop. If you did not receive this test message and would like to be included on the reflector, please contact Randy Brown at [rbrown@water.ca.gov](mailto:rbrown@water.ca.gov).

## Red Tide in Berkeley Marina Raises Concern for Toxic Blooms in Central Bay

Brian Cole, USGS and Andy Cohen, SFEI

The development of a red tide in parts of Central San Francisco Bay during August 1997 suggests that the bay may be susceptible to the harmful algal blooms that have been reported with increasing frequency in estuarine and coastal waters throughout the world. "Red tide" generally refers to a bloom of microscopic floating organisms that may result in conditions ranging from simple discoloration of the water to the buildup of noxious (foul smelling) or toxic substances. These substances can contaminate mussels and other bivalves, kill fish and other animals, and even be toxic to humans.

Many phytoplankton, including diatoms and blue-green algae, can form noxious or toxic blooms, although red tides are usually caused by dinoflagellates. These microscopic organisms generally have been classified as plants, although recent research suggests that they would more appropriately be classified as protists (which have characteristics of both plants and animals).

Researchers have reported a dramatic worldwide increase in the incidence of red tides since the late 1960s, with such blooms occurring more frequently and in regions where they were not previously reported (Smayda 1990; Cullota 1992; Hallegraeff 1993; Milot 1997). These blooms have caused temporary closures of shellfisheries, sometimes with substantial monetary losses; illness in people who ate contaminated shellfish or, in a few cases, simply breathed the sea air; and some fatalities.

At least part of the increase in red tides is believed to be due to increased nutrient levels in estuarine and coastal waters from sewage effluent,

agricultural runoff, or other anthropogenic sources; some recent red tides may have resulted from introduced exotic dinoflagellates arriving via ballast water exchanges.

In early August, Cliff Marchetti, waterfront manager for the city of Berkeley, and patrons of the Berkeley Marina noticed the presence of "red-dish water" throughout the marina, located on the east shore of Central Bay. Initially, the red water appeared with high tides and disappeared during low tides, but after a few days water in the marina remained continuously discolored. Noxious odors developed and organisms that had been growing on the sides of the floats and pilings sloughed off.

These observations raised concerns about potential impacts on fish and other organisms, and on people who worked in contact with the water or were exposed to the noxious odors. Reddish water was also reported in Oakland's Outer Harbor, and boat operators reported streaks of red water in the open waters of Central Bay.

On August 22, about two weeks after red water had first been observed in the Berkeley Marina, we measured water conditions and collected water samples at the marina and at Estuary Park in Oakland's Inner Harbor. Throughout the Berkeley Marina, the water color was a deep reddish brown and the phytoplankton community was almost entirely composed of the dinoflagellate *Gymnodinium sanguineum* (= *splendens*), a species known from tropical and subtropical coastal waters around the world.

Cell densities of *G. sanguineum* were approximately 2,600 per mL at the water's surface and 140 per mL at the

bottom. Similarly, chlorophyll concentrations were much higher near the surface (70 - 140  $\mu\text{g/L}$ ) than near the bottom (10  $\mu\text{g/L}$  at 6 meters depth), possibly due to dinoflagellates swimming towards the light. An observed gradient in midday dissolved oxygen concentrations (10.6 mg/L at the surface and 5.3 mg/L at the bottom) was probably due to higher levels of photosynthesis near the surface. The salinity was 29 psu and the water temperature was 22.2°C. This high water temperature in the marina coincided with the highest water temperatures we have recorded in Central Bay in 28 years, a local result of the 1997 El Niño event. On the Peruvian coast, *G. sanguineum* blooms are associated with temperatures of 17-23°C and salinities of 35 psu (Rojas de Mendiola 1979).

We found no evidence of a red tide at Oakland's Estuary Park. Chlorophyll levels (3 - 4  $\mu\text{g/L}$ ) were normal

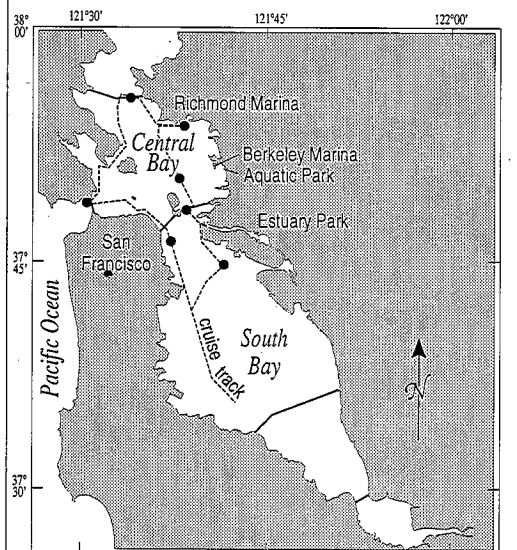


Figure 1  
The cruise on August 26, 1997, circled the perimeter of Central Bay. Red colored water was only seen at the entrance to the Richmond Marina, although *Gymnodinium sanguineum* was found at every site where a preserved sample was collected. • Preserved sample collection site.